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REVIEW OF RESEARCH ON THEORY OF TEACHING

s. p. bhattacharya

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REVIEW OF RESEARCH
ON
THEORY OF TEACHING

STATE INSTITUTE OF EDUCATION
Govt of West Bengal

By
S. P. Bhattacharya

CENTRE OF ADVANCED STUDY IN EDUCATION
Faculty of Education and Psychology
The M. S. University of Baroda
BARODA (India)
1973

case monographs series

General Editor : **M. B. Buch**

30.7.93
7189

~~9447~~

Price Rs. ~~5/-~~
6/50

Printed by Shri B. M. Shah, Manager, The Maharaja Sayajirao University
of Baroda Press (Sadhana Press), near Palace Gate, Palace Road, Baroda
and published by Dr. M. B. Buch, Head, Centre of Advanced Study in
Education, M. S. University of Baroda, Baroda, November 1973.

FOREWORD

The contemporary research in Social Sciences is characterised by a distinct emphasis on developing theories in their respective fields with a view to understanding and solving problems confronting them. In the special field of educational research, efforts to develop a theory of teaching have been noticed since Barr's pioneering work on teacher effectiveness. By the end of the sixties a good number of studies on the concept and theory of teaching have come out and these can be viewed as being part of the over-all attempt to understand and solve the problem of teaching.

In the Centre of Advanced Study in Education, " Teaching " has been taken up as one of the three major areas of research and a band of researchers are working on various aspects of it. Their work is directed towards the ultimate goal of a serviceable, empirical theory of teaching, especially in Indian conditions. The present monograph is a broad review of literature in that context. It brings together the current thoughts on the concept of an empirical theory of teaching, the methodology of research and the problems in developing such a theory. It will also serve the purpose of an up-to-date source of reference to some basic studies, in this area. In this way, this little monograph will, no doubt, be helpful to students of educational research, especially those interested in research on teaching.

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INTRODUCTION

Research on teaching now constitutes a major area of Educational research. Major contributions clarifying the concept of teaching and building firsthand theories of teaching are coming forth in recent times. (Barr, 1961 ; Bellack and associates, 1963 ; Biddle, 1964; Bruner, 1966; Flanders, 1965; Gage, 1963; Hickey and Newton, 1964; Jackson, 1966; Mitra, 1970; Ryans, 1965; Skinner, 1954; Smith and Meux, 1963; Stolurow, 1965; Travers, 1966; and others).

In the face of burgeoning number of collection of papers on the concept and theory of teaching and their publications in journals, seminar-reports and other forms of research dissemination, it is difficult for a researcher in teaching, to keep abreast of the classical papers on theories of teaching as well as with the new important developments in the field. The author, therefore, at this juncture considers it desirable to prepare a research monograph on theory of teaching that will contain a general overview of the theoretical concept, the methodology and the content of various empirical studies on theories of teaching and within this frame-work the pertinent issues and controversies they have generated along with an exhaustive bibliography.

It is obviously impossible to cover the whole range of efforts towards developing a theory of teaching, even in a somewhat superficial manner. The author, conscious of the limitations of his power, has more often than not used the key concepts of the contributors and has also extracted from their original writings. His purpose was not to generate knowledge, but the prelude to it, that is, collation of all available knowledge. Again, the monograph is not a complete compilation of rudiments of all the materials on theories of teaching. No single booklet can be all-inclusive. Some research works being too detailed and technical could not be included in this monograph, but they are mentioned in the bibliography. Certain material is not available in India and some is left out through oversight.

Theories or models of teaching are not few and presently, each theory, at best a group of theories, appear to exist within its closed system and resist direct comparison and pooling of data. Concepts and techniques of each sub-set of theories of teaching are peculiar to the school of research to which they belong and cannot be drifted out of their own frame of reference. But this is partly due to the complexity of the nature of teaching and partly due to the personal attempts at theory construction. Because of numerous personal attempts, today the research in this area has a vast front but little depth. No doubt, vigourous individual attempts to build theories have some special virtues. But these produce only limited theories. A comprehensive theory of teaching will emerge out of the sub-sumption of these limited theories. For this a long drawn programme of collaborative research is needed. The author hopes that the monograph will be a contribution, however small it may be, towards crystallizing out from such inchoate theories of teaching some basic theory of teaching process which all reasonable persons in the field could accept.

The author likes to record his sincere thanks to Mrs. S. S. Padhye, the Librarian of CASE for her valuable help to find out references, to Miss S. Sharma and Miss G. Mubayi, Research Fellows of CASE for their friendly co-operation to prepare the bibliography. Finally, the author acknowledges his indebtedness to Professor M. B. Buch, Head of CASE, for his constant guidance and encouragement.

November, 1973

S. P. B.

CONTENTS

Foreword iii

Introduction v

Part I : Preliminary Concepts

1.1 Definitions of Teaching 1

1.2 Nature and Components of Teaching 4

1.3 Definitions and Types of Theory 11

1.4 Nature of a Theory of Teaching 14

Part II : Evolving Concepts of a Theory of Teaching

2.1 Need for a Theory of Teaching 17

2.2 Neglect of Building a Theory of Teaching 18

2.3 Criteria for Evaluating a Theory of Teaching 21

2.4 Relation of Theories of Learning to Theories of Teaching 24

2.5 Towards Psychological Models of Teaching 30

2.6 Towards Mathematical Models of Teaching 40

Part III : Conclusions

3.1 Retrospect 47

3.2 Prospect 51

Bibliography 58

PART I

PRELIMINARY CONCEPTS

1.1 Definitions of Teaching

Teaching is a complex activity carried on in the complex situation of the school, by complex organisms,—human beings (teachers) directed towards more complex organisms (students), who are constantly undergoing complex changes. It is, therefore, natural that it would constitute one of the most important but frustrating areas of Educational research.

The fundamental reason of frustration of researchers in this area is due to a lack of clear concept of the complex process *i.e.* teaching. One may say, while teachers tried to teach and researchers tried to understand and improve it, nobody seemed to know exactly what teaching is. In this context, Barr (1961) very interestingly said that, "teaching means many different things, that the teaching act varies from person to person, and from situation to situation". The confusion on the concept of teaching may be grasped from the following representative samples of the definition of teaching.

Various Definitions

(1) "Teach : impart knowledge or skill ; give instruction or lesson ; instil, inspire with "

(Little Oxford Dictionary)

(2) "Teaching : the art of assisting another to learn. It includes the providing of information (instruction) and of appropriate situations, conditions, or activities designed to facilitate learning."

(English & English, 1958)

(3) "Teaching : intimate contact between a more mature personality and a less mature which is designed to further the education of the latter."

(Morrison, H. C., 1934)

(4) " ...., teaching is a system of actions involving an agent, a situation, an end-in-view, and two sets of factors in the situation—one set over which the agent has no control (for example, size of classroom and physical characteristics of pupils) and one set which the agent can modify with respect to the end-in-view (for example, assignments and ways of asking questions).

(Smith, B. O., 1963)

(5) "..... a description of teaching as it was in progress in the classroom could be secured by defining 'teaching as interaction'. Interaction is used in its dictionary sense of mutual or reciprocal action or influence."

(Hughes, M. M., 1963)

(6) "Teaching is, ..., an interactive process, primarily involving classroom talk, which takes place between teacher and pupils and secures during certain definable activities. The teaching activities recognized here are : motivating, planning, informing, leading discussions, disciplining, counselling and evaluating.

(Amidon and Hunter, 1967)

(7) "Teaching behavior, by its very nature, exists in a context of social interaction. The acts of teaching lead to reciprocal contacts between the teacher and the pupils, and the interchange itself is called teaching."

(Flanders, N. A., 1970)

(8) "Teacher behavior will genotypically be defined in terms of a set of hypothetical constructs which are assumed to characterize the teacher system and which are postulated to interact and mediate the observable teaching response in a particular situation. The functioning of the teacher-system is described as teacher information processing, information forwarding, and information control."

(Ryans, D. G., 1965)

(9) "Instruction is a process for the implantation of a structure in mind. This in-structuring results from a search for meaning in the structure. This search forms a coherent ternary system which has as components the idea, the 'mind' of the instructor, and the 'mind' of the learner."

(Searles, J. E., 1967)

(10) "Teaching: arrangement and manipulation of a situation in which there are gaps or obstructions which an individual will seek to overcome and from which he will learn in the course of doing so."

(Brubacher, J., 1939)

(11) ".... arranging the conditions of learning that are external to the learner. These conditions need to be constructed in a stage-by-stage manner, taking due account at each stage of the just previously acquired capabilities of the learner, the requirements for retention of these capabilities, and the specific stimulus situation needed for the next stage of learning."

(Gagné, R. M., 1965)

(12) "Teaching is the arrangement of contingencies of reinforcement under which students learn. They learn without teaching in their natural environments, but teachers arrange special contingencies which expedite learning ,hastening the appearance of behavior which would otherwise be acquired slowly or making sure of the appearance of behavior which might otherwise never occur."

(Skinner, B. F., 1968)

(13) ".... teaching is the arrangement of situations which lead to desirable bonds and make them satisfying."

(Thorndike, E. L., 1913)

(14) "..... teachers were viewed as professionals specializing in the performance of a particular body of tasks

or problems. These problems were thought of as involving the union of two broad variables : (1) instructional goals (behavioural expectancies) held desirable by some person or group, and (2) pupils at particular levels of development. This broad perspective of teaching implies that teachers engage in two central activities : (i) goal setting, and (ii) instrumental responding, to actualize these goals. The former was identified as problem-creating activities, the latter as problem-resolving activities."

(Turner, R. L., 1964)

(15) "... teaching is a rule guided activity, or as I shall say, it is norm-regarding."

(Green, T. F., 1964)

(16) "By teaching, we mean, ... any interpersonal influence aimed at changing the ways in which other persons can or will behave. The restriction to 'interpersonal' influence is intended to rule out physical (*e.g.* mechanical), physiological, or economic ways of influencing another's behaviour, such as, pushing him, drugging him or depriving him of a job. Rather the influence has to impinge on the other person through his perceptual and cognitive processes, *i.e.* through his ways of getting meaning out of objects and events that his sense make him aware of."

(Gage, N. L., 1963)

All in all, these definitions may be classified broadly in three types as mentioned by Mitra (1970) :

(i) It is imparting knowledge or skill.

(ii) It is doing anything and everything that may lead to learning.

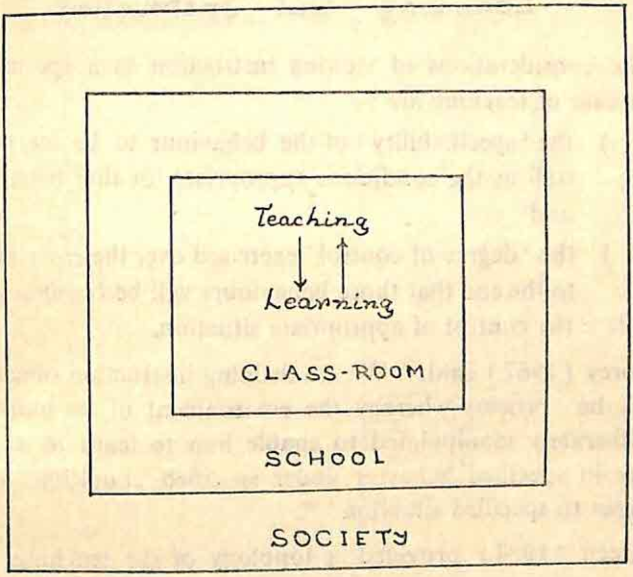
(iii) It is a social act of influence.

1.2 The Nature and Components of Teaching

Teaching originated at the dawn of human civilization as the first vocation of man. Its evolution runs parallel to that of human civilization in terms of its growing complexity and variety. As a result, the concept of teaching has changed quite a lot since its beginning as simple direction, to indirect stimulation and presently to highly organized function of a body of professionals. In this context, Mitra (1970) said that teaching was the essential act of a teacher, mainly carried out within the environment of school or college or university, an institution of society. There the teacher does a service (an act of teaching) to his clients (students) either individually or in groups and this he does in a formal, systematic manner.

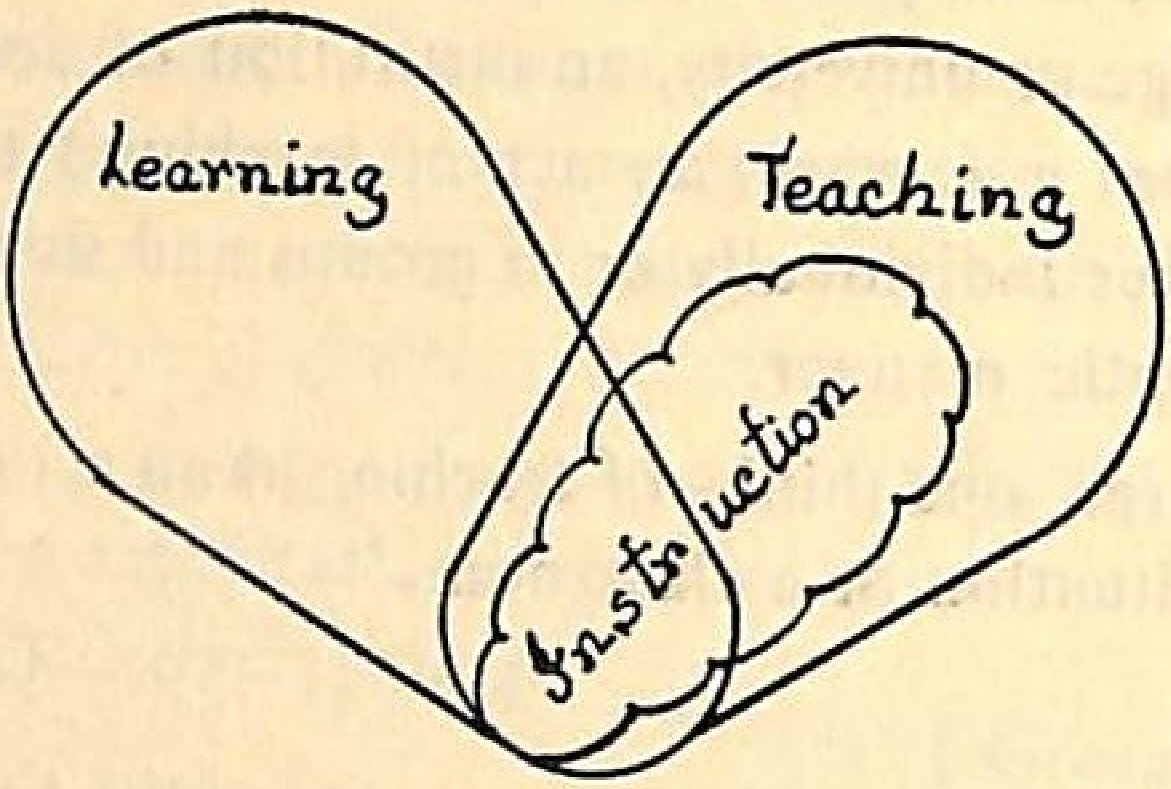
> " By and large, one thinks of teaching as an act of instruction in the formal situation of a classroom. "
>
> (Mitra, 1970)

N. L. Gage (1964) mentioned that ' teaching is a misleading generic term: it covers too much. Instruction is, therefore,



[Fig. 1. Teaching, School and Society.]

defined as 'a special kind of teaching that has specificity of purpose and an orderliness, that does not characterise all teaching. Teaching and instruction and learning are clearly not interchangeable concepts. This relationship is pictured in figure 2.



[Fig. 2. Relationship between Teaching and Learning and Instruction]

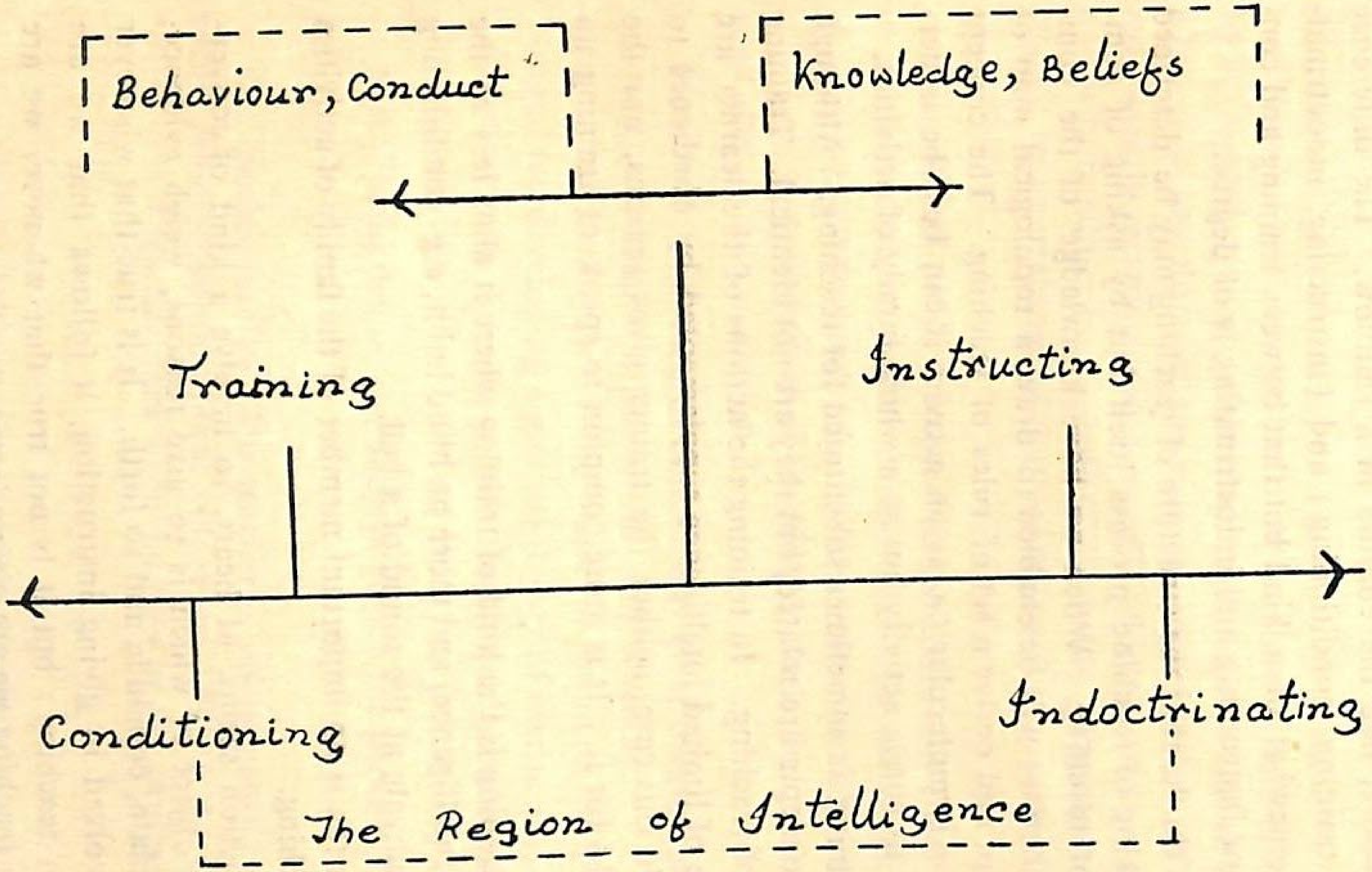
The considerations of viewing instruction as a special, but major case of teaching are :

(i) the 'specifiability' of the behaviour to be learned as well as the conditions appropriate for that behaviour; and

(ii) the 'degree of control' exercised over the environment to the end that those behaviours will be brought under the control of appropriate situation.

Corey (1967) said, " We are defining instruction operationally as the 'process whereby the environment of an individual is deliberately manipulated to enable him to learn to emit or engage in specified behavior under specified conditions or as responses to specified situation ' ".

Green (1964) provided a topology of the teaching. His continuum gives a concept of teaching which is open-textured i.e. not perfectly bound by rules. His continuum of teaching indicates four distinct stages : Conditioning, Training, Instruct-



[Fig. 3. The Teaching Continuum of Green.]

ing and Indoctrinating. The distinction between the four concepts is not clear and precise and each blends imperceptibly into its neighbours, like the colours in a rainbow. The difference between (training, conditioning) and (instructing, indoctrinating) is somewhat of a kind but that between training and conditioning or instructing and indoctrinating is of degree.

Green thinks that the structure of teaching may be described not by asking of teaching process itself but by asking of components of teaching. When we have knowledge of the components, then we will be enabled to draw a topological map of the concept and derive a set of rules of teaching. The concept of teaching is molecular *i.e.* as an activity it can best be understood not as single activity but as a whole family of activities.

Training is sometimes substituted for teaching. Although the two concepts are related, but they are not identical. Training is a part of teaching. In training the actions of the learner are expressive of limited intelligence supplemented by obedience to orders. In this case, neither the trainer gives reasons, nor the trainee asks for it. It is more common to speak of training an animal.

Conditioning is the kind of training where it aims less at the display of intelligence, and more on blind habit, *e.g* conditioning a dog to salivate at the sound of a bell.

Instruction is an important member of the family of activities called teaching.

"Instruction seems, at heart, to involve a kind of conversation, the object of which is to give reasons, weigh evidence, justify, explain, conclude and so forth. It is true that whenever we are involved in giving instruction, it follows that we are engaged in teaching : but it is not true that whenever we are engaged in teaching we are giving instruction".

Instruction involves a kind of conversation, a giving of reasons, evidence, and so on, it is, therefore, unlike training, an activity allied to the acquisition of knowledge and belief than to the promotion of habits and modes of behaviour. If the goal of teaching is the pursuit of truth, instruction is then central in the process of teaching.

When the communication of instruction is less characterised by agreement, reasons, objection, explanations and so forth, and when it is less directed towards an apprehension of truth, it more clearly resembles what we call indoctrination. Indoctrination is to conditioning, as belief is to habit. People are indoctrinated to a certain belief, but conditioned to a certain mode of behaviour.

MacDonald (1965) pointed to the confusion about the word instruction, especially when considered along with such concepts as teaching, curriculum and learning. He asks: what is instruction ? Is it a sub-aspect of teaching ? Is it the act of putting a curriculum into operation ?

He refers to the lack of consistently clear distinction between teaching, curriculum, instruction and learning. A common agreement, upon at least the basic phenomena in teaching is required for developing a general theory of instruction. To this end, the concept of systems and boundaries between systems as suggested by Parsons and Shils (1952) may fruitfully be used.

MacDonald defines the sub-systems in the process as follows:

Teaching :

The teacher teaches. The teacher is a personality system with needs, pre-disposition, unique values etc. What the personality system called teacher does when he acts in his professional role is teaching.

Learning :

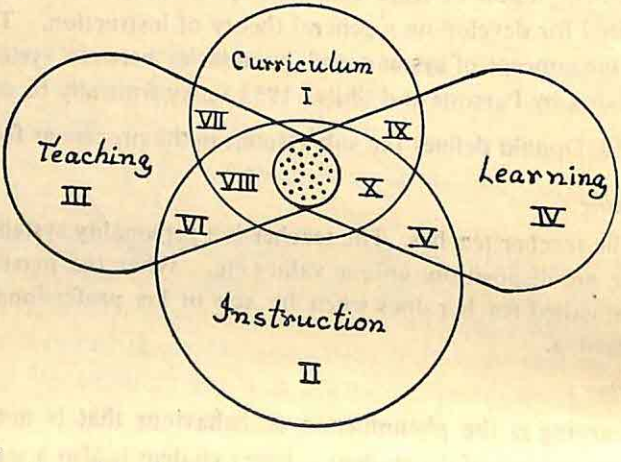
Learning is the phenomenon or behaviour that is noted in the performance of the student. Every student is also a separate personality system with unique pattern of needs, values, past experiences, perception, etc. Actions that students perform which teachers perceive to be task related are learning behaviours. Learning is primarily system (student : personality) related and only secondarily related to teaching.

Instruction :

The teaching-learning system is more aptly called the instructional system. The instructional system is a social system, rather than a personality system. The instructional system usually is bounded by a classroom with a teacher, a group of students, materials, social norms, etc. It is the action context within which formal teaching and learning behaviour takes place. The instructional system is made up primarily of classroom action units.

Curriculum :

The curriculum system consists of persons who are a part of a social system which eventuates in a curriculum, in the sense of plans for action. The important distinction for purposes here, is the boundary between curriculum and instruction. They are essentially two separate action texts, one (curriculum) producing plans for further action; and the other (instruction) putting plans into action.



[Fig. 4. Macdonald's diagram of action space of four systems: Curriculum, Instruction, Teaching, Learning.]

Figure 4 is a graphic representation of the distinction between the four aspects of teaching, made from a system's viewpoint. There are four overlapping circles in the system. Each circle shares some space with every other circle, some space with two other circles and some space with all other circles. The curriculum space (I) is illustrated by a course of study or text-book prescribed. Instruction space (II) is illustrated by unique quality of interaction in any given class. Space (III) refers to unique patterns of experiences, values, attitudes, etc. of a teacher as these affect teaching behaviour. Space (IV) represents unique experiences, values, attitudes, etc. of each individual learner as they affect learning. Space (V) is illustrated by the phenomena of concomitant learning. Space (VI) includes teacher modification of behaviour in response to the immediate feedback of the instructional situation, Space (VII) may be described as in-service experiences. Space (IX) and (X) deal with pupil-teacher planning experiences. And finally, " the small shadowed spot represents that point of congruence where curriculum goals are operative in the instructional setting through the agency of effective teaching activity as evidenced by the changed behaviour or learning of the students. " MacDonald writes that because of our zeal to arrive at student learning, we have skipped the essential distinction between the aspects of the system and have focussed our attention myopically upon the area of congruence.

To sum up, MacDonald's system approach for defining teaching, views learning as the desired response, teaching as "the act of systematically presenting stimuli and/or cues"; instruction as " the total stimulus setting within which systematic stimuli and desired responses occur", and curriculum as "the major source of stimuli found in instructional setting to be utilized systematically."

1.3 Definition and Types of Theory

The lexical meaning of theory is " supposition to account for something : system of rules and principles, rules and reasoning, etc. as distinguished from practice." (Collins English General Dictionary, 1960).

The Encyclopaedia Britanica (Vol. 22, 1964) gave under "Theory": "It signifies a systematic account of some field of study, derived from a set of general propositions. These propositions may be taken as postuates, as in pure mathematics (theory of function etc.) or they may be principles more or less strongly confirmed by experience, as in natural science (theory of heat, electromagnetic theory).

Macia (1965) wrote: "Theory is taken to be a systematically related set of statements. To be systematically related is obviously to be organized. The paradigm of organization is a deductive system — — —. In fact, formal coherence is a criterion of adequate theory, no matter what kind of theory it is."

Skinner (1950) defined "Theory" as "a formal representation of the data reduced to a minimal number of terms."

Gage (1963) wrote about theory in his Handbook as thus:

"In this chapter, we use the term theory in a modest sense—to refer to any systematic ordering of ideas about the phenomena of a field of inquiry. We use the term in antithesis to ad hoc, disorderly planning or interpretation of research ....."

Types of Theory

Researchers in behavioural science refer at least three different types of theory. Ryan, D. G. (1956) identified two types as (1) the axiomatic or hypothetico-deductive type: and (2) the empirical, inductive type. He has brought out the elements of the two types in a table, which is reproduced on opposite page:

Newsome (1964) referred to two types of theory: (1) scientific theory and (2) axiological or philosophical theory.

Maccia (1965) referred to (1) formal theory—theory of pure logic and pure mathematic, (2) descriptive theory—theory of philosophy. She wrote: "Theories may be either formal or descriptive or prescriptive. The statements of a formal theory—

theories of pure logic and pure mathematics—are given no meaning: they are not interpreted. The statements of a descriptive theory—theories of empirical science—are given meaning through what is: they are interpreted experimentally. The statement of a prescriptive theory—theories of philosophy—are given meaning through what ought to be: they are interpreted ideally."

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TABLE I

Theoretical Framework

Type I : Axiomatic, Mathematico-Deductive, Hypothetico-Deductive Theory	Type II : Inductive, Empirical Theory
A. Assumptions Definitions.	A. Assumptions, Definitions (especially 'operational')
B. General propositions.	B. Observation, Classification and cross-classification. Sporadic hypotheses and their experimental testing.
C. Hypotheses: postulates and theorems properties and functional relationships.	C. Specified descriptions of properties and functional relationships (Generalizable to inductive principles and laws).
D. Observations; testing of postulates and theorems by classification and experimentation.	D. Systematization, Organization of descriptive principles into coherent pattern. (Possibly leading to general proposition).
E. Extension and revision of theory in light of observation and of further deductive analysis.	E. Extension and revision of principles, and of theory, as required by further classification and experiment.
F. Prediction.	F. Prediction.

According to Hyman (1971), the theories of teaching are developed along three distinct lines:

1. Axiomatic, formal, very often simply called scientific theory.
2. Inductive, empirical, descriptive theory.
3. Philosophical: prescriptive or humanistic or axiological theory.

1.4 The Nature of a Theory of Teaching

The term theory is used in teaching as it is used in the natural sciences to represent a set of interrelated generalizations derived from data, which permit some degree of prediction or control over the phenomena to which they pertain.

In this monograph, the word 'teaching' refers to activity which takes place during schooling and within classroom setting. The term includes both material variables and human variables. It refers to the interaction between teacher, pupils and situational elements.

Bruner (1966) prepared some valuable notes on a theory of instruction.

"A theory of instruction is 'prescriptive' in the sense that it sets for the rules concerning the most effective way of achieving knowledge or skill. By the same token, it provides a yardstick for criticizing or evaluating any particular way of teaching or learning."

"A theory of instruction is a 'normative' theory. It sets up criteria and states the condition for meeting them. The criteria must have a high degree of generality."

Bruner (1968) further elaborated the 'prescriptive' and 'normative' characteristics of theory of instruction in the following words: "Such a theory has the aim of producing particular ends and producing them in ways that we speak of an optional. It is not a description of what has happened when learning has taken place—it is something which is normative, which gives you something to shoot at and which, in the end, must state something about what you do when you put instruction together in the form of courses."

Travers (1966) conceived of a theory of instruction "as consisting of a set of propositions stating relationships between, on the one hand, measures of the outcome of education and, on the other hand, measures of both the conditions to which the learner is exposed and the variables representing characteristics of the learner."

He classified the major independent variables of his model into four main classes: pupil variables, pupil task variables, teacher variables, and teacher task variables.

Following the same vein as of Bruner and Travers, Maccia (1965) wrote: "To theorize about instruction, therefore, involves a choice as to whether the organized account shall be of instruction as it is or as it ought to be. Shall the theory be a scientific or a philosophic one? I selected the former alternative. The reason for the selection is that without a mean of control, ideas as to how the phenomena we are dealing with are related, we have no basis for implementing a philosophic theory of instruction no matter how adequate that philosophic theory might be. A scientific theory of instruction, if adequate, provides such a basis."

Bruner (1968) proposed that there are four aspects of such a theory.

First, a theory of instruction should concern itself with the factors that pre-dispose a child to learn effectively. These factors relate to his earliest childhood and these proceed the child's entry into our scholastic care.

The second aspect of the theory of instruction is that it should concern itself with the optimal structuring of knowledge. By this, he means that for any body of knowledge there is a minimal set of propositions, or statements, or images from which one can best generate the rest of what exists within that field.

For example, from the conservation theorems plus a little more, a great deal of physics can be re-constructed.

A third aspect of a theory of instruction deals with the optimal sequence that is required for learning. ....In what order do we present things ?.... What exercises do you give the child to strengthen the views of his own thinking? What type of representation do you use? How much particular? How much generality?

Finally, a fourth aspect of a theory of instruction should concern itself with the nature and pacing of rewards and punishments and successes and failures.

To sum up then, a theory of instruction should be constructed around four problems: pre-dispositions, structures, sequences, and consequences. Travers holds that data of such a theory must be closely related to the phenomena of the classroom. The dependent variables of the system should be specified in terms of tasks and not in terms of behaviour.

In this context Smith's (1965) specification of the contents of a theory of teaching may be quoted : " A theory of teaching will consist in (a) a statement of the variables comprising teaching behaviour ; (b) a formulation of the possible relations among these variables : and (c) hypotheses about the relations between the variables comprising teaching behavtour and the variables descriptive of the psychological and social conditions within which teaching behaviour occurs. "

In conclusion, it may be said that the theory of teaching should consist of general principles which have been derived from the experiences of teachers, observations of the classroom as well as from experimental evidence and reason.

PART II

EVOLVING CONCEPTS OF A THEORY OF TEACHING

2.1 Need for a Theory of Teaching

The utility of a theory of teaching in research on teaching may be summed up as follows : It is a guide to the formation of research hypotheses in teaching that may be tested in practical context. It trains investigators to look for facts which may not be readily apparent. It cumulates research work, allowing old studies to gain support from new studies. Above all, it makes possible the conclusions to take shorthand form and thereby helping communicability between the researchers themselves as well as between the researchers and the practitioners in teaching.

Next, one might ask the question why the teachers need a theory of instruction, since psychology already contains theories of learning and development. Bruner (1966) said in this connection, that the teachers do not need a descriptive theory which learning theories really are, but they need a prescriptive theory.

" — — — — — — — theories of learning and development are descriptive rather than prescriptive. They tell us what happened after the fact, for example, that most of children of six do not yet possess the notion of reversibility. A theory of instruction, on the other hand, might attempt to set forth the best means of teaching the child towards the notion of reversibility. A theory of instruction, in short, is concerned with how what one wishes to teach can best be learned, with improving rather than describing learning. "

About the role of theory as systematizer and binder of research efforts, the following quotation from the report of the Committee on the Criteria of Teacher Effectiveness, (1953) will do :

"......at present, research too often proceeds without explicit theoretical framework, in intellectual disarray, to the testing of myriads of arbitrary, unrationalized hypotheses. The studies too often interact little with each other, do not fall into place within any scheme and hence add little to the understanding of teaching process."

The Committee, therefore, concerned itself with theories and paradigms with a view to draw notice to the necessity of more systematic and orderly approaches to the research on teaching.

Guba and Gatzels (1955) wrote that a theoretical framework sharpens research objectives and suggests what variables should be eliminated as non-meaningful and hence wasteful, increases the likelihood of significant findings, simplifies the complex task of interpreting results, and makes research cumulative from one study to the next.

Kerlinger (1964) was also appreciative of the contemporary trend in building theories in education. He said that the development of theory should be the basic aim of research in education. Theories, he contained, have wider applicability and usefulness than non-theoretical findings do.

All in all, the need for theory of instruction may be summarised in the following statements :

1. A theory of teaching helps to clarify the description of the teaching-situation in ordinary language.
2. It summarizes existing knowledge.
3. It mediates applications of our knowledge of teaching to new situations.
4. It leads to fruitful line of experimental inquiry.

22. Neglect of Building a Theory of Teaching

Gage (1963) mentioned that in general the neglect of a theory may be due to a lack of understanding about the nature of theory, lack of awareness as to the benefits of a theory, lack of technical language for theorizing and a fear of theorizing.

Gage claims that the neglect of theories of teaching is specifically due to (a) the belief that the development of such theories implies a science of teaching in contrast to an art of teaching, which many writers accept and (b) the presumption that theories of learing are sufficient and adequate for the teacher.

Skinner (1968) mentioned of ' the Science of Learning and the Art of Teaching '. If teaching is an art, it is much less susceptible to practical generalizations than we would wish it to be.

Highet (1963) argued forcefully that teaching is an art and therefore attempts to build a set of scientific principles of teaching are bound to be futile.

" .... I believe taching is an art, not a science. It seems to me very dangerous to apply the aims and methods of science to human beings......... ' Scientific ' teaching, even of scientific subjects, will be inadequate as long as both, teachers and pupils are human beings. "

Thompson (1969) pointed to this reason of negligence of building theory of teaching in the following words :

" One of the first obstacles we encounter along the path to a theory of instruction is the dilemma that has stymied so many would be educational theorists in the past: namely, that teaching may be an art, rather than a science. "

Undue emphasis on learning theories in the process of teaching-learning situation is another reason of neglect of building the theory of teaching.

Gage (1963) wrote: " Some have seen on strictly logical ground, any theory of teaching as unnecessary. They say that if we have an adequate theory of learning, then the teacher must of necessity act upon that theory, without employing any separate theory of teaching. The teacher, if he is to engender learning, must of necessity do what the theory of learning stipulates as necessary for learning to occur. Teaching must thus be a kind of ' mirror image ' of learning. "

Early psychologists believed that theory of teaching, unlike theory of learning, cannot be generated directly out of their science. Teaching is carried on in classrooms, the situation which is difficult to be experimentally controlled. Writing in 1899, William James said: " Psychology is a science and teaching is an art; and science never generate art directly out of themselves. "

About lack of technical language required to build a theory of teaching, Travers (1966) had the following case to make : " No theory of instruction, nor the deductions of optimum conditions can have merit unless the dependent variables of the system are well defined. "

" Language already available seems capable of taking us far in the development of the dependent variables of an educational theory......In contrast, the independent variables of a theory of instructions cannot be discussed except in the most general term at this time because of a lack of the emergence of a technical vocabulary. "

According to Travers, languages useful for theory construction cannot be evolved by analytical approaches. Newton evolved such technical terms for physics like mass, velocity, force, etc. as he worked on the vast amount of data gathered on motions of heavenly bodies for writing the manuscript of " Principia ".

The evolution of a language for stating a theory of instruction would appear to require the medium of empirical research. Components of such a language appear to be evolving in such varied work as that of Bellack, Flanders, Hughes, Nuthall, Skinner, Smith, Taba, and others.

McMurray (1955) held the view in this connection that theory in education urgently need, not only the technical language distinctive of the discipline itself, but also an exhaustive list of basic concepts with which to judge the relevance and coherence of theories of education.

9417

Huebner (1968) identified 6 categories of language, analysing the theoretical statements of curriculum and teaching-theorists. The types of languages according to him are: (1) descriptive, (2) explanatory, (3) Controlling, (4) Legitimizing, (5) Prescriptive and (6) Affiliative.

Lastly, researchers in social science in general have occasional doubts about the usefulness of theory in research. Skinner (1959) had thrown doubt on the value of theory as means of research in the narration of his case history of himself as a scientist.

" I never attacked a promblem by constructing a Hypothesis. I never deduced Theorems or submitted them to Experimental check. So far as I can see, I had no pre-conceived Model of behaviour—certainly not a physiological or mentalistic one and, I believe, not a conceptual one. "

Skinner's idea will surely warn the researchers of the blind alleys which the hypothesized theories may lead. But Fisherian model have undisputably contributed in building theories in physical as well as social science. It will be no doubt useful in building educational theories, including theories of teaching.

2.3 Criteria for Evaluating a Theory of Teaching

Maccia (1965) gave the following criteria for judging the adequacy of a theory of instruction.

" The scientific theory to be adequate must exhibit formal coherence, observational verification, and observational predictiveness. "

A theory has, therefore, formal coherence, if its statements are systematically related. The parts of the theory must fit together or cohere. A theory has also observational verification, if its statements correspond to that which can be experienced. It is true in terms of observation. A theory has observational predictiveness if statements about what will happen in experience can be derived from it. It permits marking off other observations to be made.

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1189

The adequacy of a scientific theory, according to Maccia, should therefore be checked by a set of questions as given below :

1. Do the ideas about instruction fit together?
2. If the ideas about instruction do not fit together, could they be extended or modified or both in order to produce the fit?

   (Criteria of formal coherence)
3. Do the ideas about instruction check with experimental or non-experimental observations recorded by others or made by the experimentor?
4. If there is no evidence on whether the ideas about instruction check with observations, could experimental or non-experimental designs for checking them be devised?
   (Criteria of observational verification.)
5. From ideas about instruction, could other ideas about instruction be derived (hypotheses be stated) and could these predictions be observed (experimental or non-experimental designs for checking the hypotheses be devised)?

   (Criterion of observational predictiveness.)

Travers (1966) mentioned the following four clear-cut criteria of a good theory of instruction.

1. " First, it has to be empirically based and the propositions of the theory must have a clear relation to data. " Travers recommended in this connection a model similar to Hull's on theory of behaviour.

   > "......Hull model still reflects a pattern of relating data to theoretical proposition which seems to me admirable. "
2. " Second, a theory of instruction will have to represent the relationship between a wide range of learning conditions and achievements. Even theories of instruction

which deal with very limited areas are likely to be complex in that they will probably involve many variables. "

3. "Third, the optimal conditions would be those which maximise some function, say a linear function, of the measures of the variables defining the outcomes. The weight given to each variable would reflect a value judgment. "

4. " Fourth, a theory of instruction of any value will have to be based on quantitative data, but these data will probably be reducible to a set of verbal non-mathematical propositions. "

Rose (1954) cited in Ryan's article (1956) had this say in the context. " A good theory is one which (1) has its definitions, assumptions, and general propositions consistent, in so far as possible, with previous research findings and with careful, although perhaps not systematic, observation, (2) has a minimum number of definitions, assumptions, and general propositions ; (3) has its deduced hypotheses in readily testable form, and crucially, (4) gets its deduced hypotheses verified by proper scientific methods. "

Bruner (1964) wrote that when and if an acceptable theory of teaching is developed, it will meet atleast 4 criteria :

1. It will specify the nature of learning environment, that is, it will define the pre-conditions necessary for learning to take place.
2. It will specify how information is to be structured so as to be understood by learners.
3. It will specify the most effective sequence for presenting information.
4. It will specifly the nature and pacing of re-inforcement.

The Association for Supervision and Curriculum Development, NEA, instituted a Commission on Instructional Theory.

The Commission, with Gordon (1968) as chairman came out with 10 criteria for instructional theory. The criteria are held as standard and all-inclusive to evaluate a theory of teaching.

ASCD Criteria :

I. A statement of instructional theory should include a set of postulates and definition of terms involved in these postulates.

The statement should include pupil, goal and instructional situational characteristics, which should also be operationally defined.

II. The statement of an instructional theory of sub-theory should make explicit the boundaries of its concern and the limitations under which it proposed.

III. A theoretical construction must have internal consistency—a logical set of inter-relationships.

IV. An instructional theory should congruent with empirical data.

V. An instructional theory must be capable of generating hypotheses.

VI. An instructional theory must be verifiable.

VII. An instructional theory must contain generalizations which go beyond the data.

VIII. An instructional theory must be stated in such a way that it is possible to collect data to dispose it.

IX. An instructional theory must not only explain past events but also must be capable of predicting future events.

X. At the present time, instructional theories may be expected to represent qualitative synthesis.

2.4 Relation of Theories of Learning to Theories of Teaching

The continuous generation of knowledge on the theories of teaching and the burgeoning number of papers on it have consistently come across and therefore, solemnly raised a controversial issues in the field of instructional research.

Is teaching process a correlative of learning process ? Can a theory of teaching be built on the present theories of learning ?

The time is now ripe to take up the issue since adequate data have accumulated on it. A rationalization of this historical controversy between educational methodologists and educational psychologists will once for all settle a critical question that so far has stunted the development of a scientifically viable theory of teaching.

Learning theorists insist that principles may be drawn from various theories of learning which, drawn into the instructional process, may build a psychological model of teaching. (Guthrie, 1935; Skinner, 1950; Spence, 1956; Mager, 1962; Lumsdaine and associates, 1963; Cronbach, 1963; Gagne, 1965; and others). They in general, hold the view that teaching is a correlative term of learning and a sophisticated and accepted learning theory is a pre condition to the developing of a theory of teaching.

Silverman (1967) said in this connection that the best way to proceed in developing a theory of teaching is to start with all available research data of laboratory learning and adopting a model derived from a theory of learning. Cronbach (1963) presented seven elements of learning behaviour which, according to his view, when combined with the four essential problems in teaching will build a model of instruction. His seven elements of learning are situations, personal characteristics, goal, interpretation, action, consequences, and reaction to thwarting; and the four problems in teaching consist of the organizing of curriculum, motivating the pupils, provision of individual differences in the process of instruction and evaluation of learners' and teacher's work. Gagne (1965) has suggested that his eight types of learning are basic to individual as well as class-room teaching. His hierarchy of learning consist of signal learning, stimulus-response learning, chain learning, verbal association, multiple discrimination, concept learning, learning of principles and problem-solving. The hierarchy relates learning to the content of instruction in an orderly manner and the sequencing leads itself well to the three essentials in instruction, creating pre-condition of learning, managing instruction and ensuring that transfer of learning will take place. Haddan (1970) had the opinion that by examining the eight hierarchically built conditions of learning, both within the learner and within the learning condition, two sets of related independent variables may be obtained for a scientific model of teaching. Bigge (1964) firmly held the view that teaching theory is a correlative of learning theory and this correlation extends from thoughtless to thoughtful modes of operation. He divides the teaching-learning continuum into three broad categories: memory-level, understanding-level and reflection-level. In a table he has shown his postulated levels of teaching and appropriate learning situations.

Level of Teaching	Nature of Learning
1. Memory	Factual materials.
2. Understanding insightful	Understandings, insights, principles, relationships, concepts, generalizations, laws, theories
3. Reflection, Problem-centred, exploratory	Properly acquired understandings, insights, principles, laws, theories, plus enhanced independent thinking and scientific outlook.

In general, it may be observed that educational psychologists drawn into the area of instructional research have so long worked to derive practical methods of teaching from general theories of learning, based on experimental findings.

Others have tried to reverse the process of emphasizing the need for developing a general theory of teaching in which the principles of learning which are derived from laboratory experiments are of incidental importance only, (Gage, 1964 ; Bruner, 1966 ; Scandura, 1966 ; Siegel, 1971 ; and others).

Such a consideration has led Hilgard (1964) to reject the belief that sophisticated learning theory is a pre-condition to any systematic principle of instruction. Wright Brothers first flew the aeroplane, then the basic concepts of aerodynamics grew up.

Gage (1964). on the other hand, had advanced justification on historical grounds for irrelevance of theories of learning to theories of teaching, pointing to the past failure of learning theories to provide a psychologically relevant basis for pedagogical practices. The learning experiments in the behaviourists' laboratory and their extrapolation in the classroom situations have largely failed to solve many of the problems of instructional needs. He, therefore, distinguished between teaching process and learning process. Theories of learning aid in furthering the understanding, control and prediction of learning behviour, but not in the development of a science of teaching. Teaching deals with how an individual behaves in influencing another individual to learn. According to Gage, what is required is an analysis of teaching, identifying its variables and develop a theory of teaching. In contrast to Gage's historical arguments, Smith (1960) presented a strictly logical rational for formulating theories of teaching. According to his view, teaching is logically distinct from learning by its purpose, process and acts. A theory of learning does not tell the teachers how to teach. Granting that a descriptive theory of learning exists, it is not a sufficient condition to acquire control of the phenomenon of classroom teaching for all practical ends. Scandura (1966) advaned arguments to support the points of view of Gage and Smith. According to him, some learning principles are of incidental importance to a theory of teaching but many teaching concepts have no direct counterparts in learning theories. Techniques like task-analysis and sequencing which find no prominent place in learning theory could form important ingradients in building a lasting theory of teaching. He has rightly, identified the inconsistency of reducing molar teacher behaviour to molecular

S-R learning principles. Teaching theory basically operates at a molar level, and therefore attempts to build a theory of teaching based on the existing S-R theories of learning is unlikely to be fruitful. Bruner (1966) had taken the stand that a theory of instruction must differ from descriptive theories of learning by being prescriptive and normative. Such a theory is concerned with how what one wishes to learn can best be taught, with improving rather than describing learning. The theory should specify the experience that pre-disposes the individual toward learning. the ways in which a body of knowledge should be structured, the most effective sequences in which to present the materials, and the nature and pacing of rewards and punishment. According to him, learning theory is not a theory of teaching. It describes what happened. A theory of instruction is a guide to what to do in order to achieve certain instructional objectives. Siegel (1971) compared learning theory and didactic on four counts to show the intrinsic dichotomy in the two.

Learning and Teaching Compared

	Learning Theory	Didactic
1. Dimension	Micro Unit	Macro Unit
2. Environment	Divergent conditions	Particular convergent conditions
3. Structure of information	Limited, restrictive and simple	Rich in organization and hierarchical order
4. Purpose	Descriptive, general laws of behaviour change	Prescriptive, maximise performance in specific, natural settings

The instructional researchers who have refused to accept the existing theories of learning as model of theory—building in teaching admit the limited credits of S-R formula to provide systematic, reasonable explanation of reflexive, "biosocial"

(Schneirla, 1946) human behaviour and to provide a fundamental analytic tool to distinguish cognitive, "psychosocial" (Schneirla, 1946) behaviour from the reflexive one.

Historically, the research on teaching theory borrowed heavily from the rich treasure of S-R theories of learning so far as the language, methodology and evaluating practices are concerned. With the building up of rudiments of a theory of teaching, the realization dawned on the mind of the researchers that the initial advantages would not persist in future in more serious scheme of things. Learning theory research is basic and directed to a search for consistent explanation, whereas teaching theory research is applied and seeks to search for more adequate statement of the problem of instruction and its regulation. The present trend in building a theory of teaching points towards decreasing attachment to old, unproductive field of S-R theory and a vigorous exploration into the new fertile field of cognitive psychology. (Festinger, 1957; Wallach, 1958; Kendler and Kendler, 1959; Galanter and others, 1960; Bruner, 1966; Ausubel, 1967 and others).

Ausubel (1967) pointed out the senseless efforts of extrapolating from laboratory studies of conditioning to classroom teaching as the root cause of the present malady in building a theory of teaching based on learning. He rather wants to build a cognative theory of classroom learning as a precursor of generalizations on teaching. Ausubel's cognitive theory of learning is concerned with the complex and meaningful types of symbolic and verbal learning that take place in school and similar learning environments. By teaching, he, therefore, understands primarily the deliberate guidance of learning process along lines suggested by relevant classroom learning theory.

In the controversy between teaching and learning, more specifically, between the relevance of S-R learning theory to cognitive theory of instruction, Hough (1967) had taken the most judicious stand. He admits that teaching and learning are distinctly different processes, but he points to the fact that, since both are inseparably related to the formal situation of the classroom, any attempt to better understand teaching exclusively would be an untenable approach to the development of a functional theory of teaching. What is needed, therefore, is not a complete severance of the traditional link between the two—teaching and learning—rather a sort of symbiosis between them in the process of building a theory of teaching.

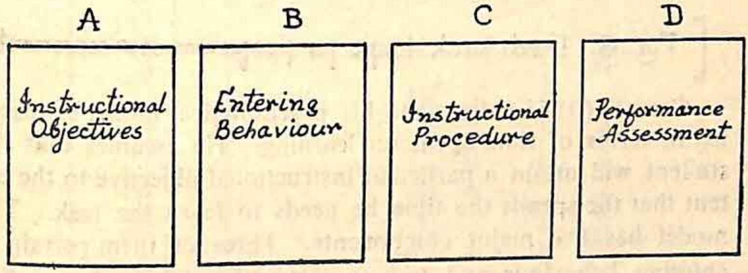
2 5 Towards Psychological Models of Teaching

Writing in 1899 in his book " Talks to Teachers " William James, a pioneer American Psychologist, said, " Psychology is a science and teaching is an art ; and science can never generate art directly out of themselves. " Until recently this distinction characterized the research in teaching. In the history of Educational Psychology, only occasional interests in teaching may be found among the researchers. As for example, Itard and Seguin tackled the problem of teaching backward children, Watson declared that he can instruct a child into whatever he wanted it to be and Carroll and Bloom declared the possibility of teaching each child complete mastery of a subject. Skinner's work in Programmed Instruction acted as a booster to the serious study of teaching among the educational psychologists. Currently, therefore, psychologists in many countries are turning their attention to problems of classroom teaching and learning. A systematic body of knowledge that might be called the psychology of teaching is gradually accumulating. Stone (1970) reported that psychological research in U.S S.R. is greatly concerned with the pedagogy of the classroom. A common Soviet thesis is, " the intervention of a teacher working with a systematic plan of instruction based on psychological principles fundamentally changes the mental activity of the child. " Galperin, P.Ia., the most influencial Soviet worker in the field of psychology of learning and teaching has the following view on the nature of teacher's influence on children's learning and thinking.

" An understanding of the concrete structure of mental action, of the laws governing their formation and the conditions for their effectiveness, of the different disturbances and methods of recovery—this is the pre-requisite of successful teaching. "

Galperin's idea provides a firm theoretical foundation for the development of effective teaching.

Robert Glaser (1962) developed a basic, psychological model of teaching. The basic teaching model divides the teaching process in to four components, corresponding to the four major sequences of events in the instructional process.

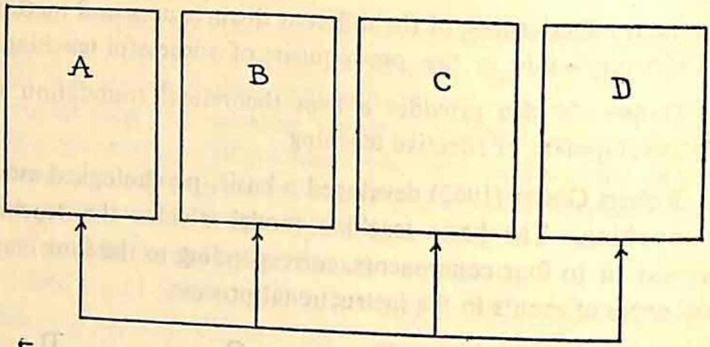


[Fig. 5. Basic Teaching Model of Glaser]

Instructional objectives (Box A) are those the students should attain after the completion of the unit of instruction. Entering behaviour (Box B) describes the students' level before instruction begins.

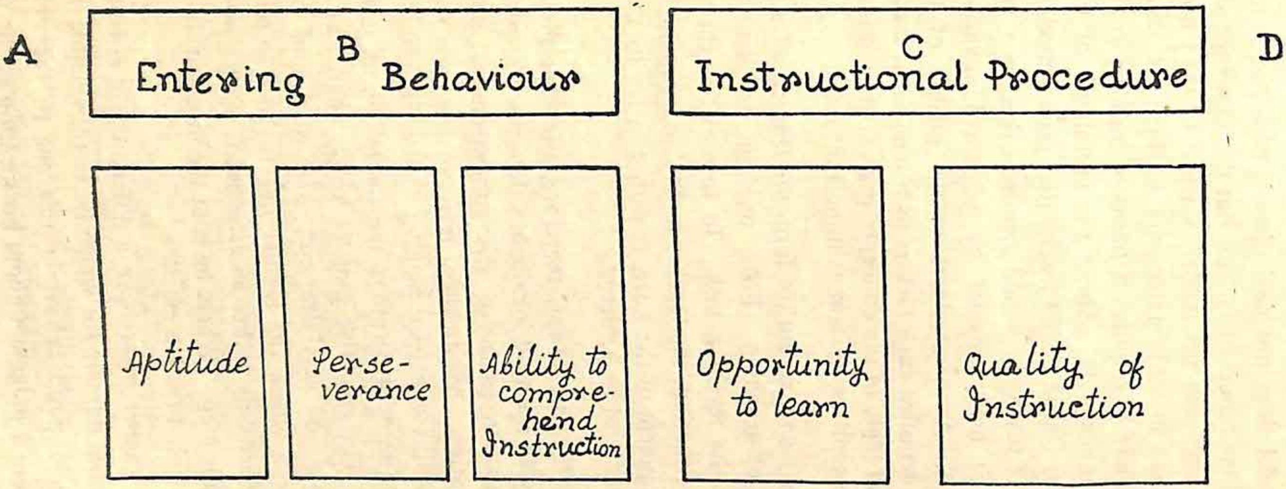
Instructional procedures (Box C) describe the teaching process itself; most decisions a teacher makes are on these procedures. Proper management of this component results in those changes in student behaviour which we call learning.

Finally, performance assessment (Box D) consists of the tests and observations used to determine how well the students have achieved the instructional objectives. If performance assessment indicates that the student has fallen short of mastery, one or all of the preceding components may require adjustment. The feedback loops in Fig. 6 show how the information provided in Box D is fed into other boxes.



[Fig. 6. Feed-back-loops for performance assessment]

Carroll (1963) described his psychological model of teaching in terms of time spent on learning. He assumes that the student will attain a particular instructional objective to the extent that the spends the time he needs to learn the task. The model has five major components. Three of them pertain to entering behaviour and two to instructional behaviour. For entering behaviour, Carroll describes the first component, aptitude, in terms of the amount of learning time the student will require to reach a particular instructional objective under optimal learning conditions. He assumes that students with high aptitude require less learning time than those with low aptitude. The second component, perseverance, is the amount of time the student is willing to spend in attaining the instructional objective. The third component, ability to comprehend instruction, refers to general, verbal intelligence of the student. Carroll's model contains two other components under instructional procedure. The first of these, opportunity to learn, is the amount of time actually allowed for learning in a teaching situation. The last component, the quality of instruction, is the degree to which the instruction is organized so that it is easily acquired by the student. Quality often depends on the clarity of teacher's language and on his adaptation to the special needs and characteristics of the students. "One can find instruction of high quality in text-books, film, workbooks, and teaching — machine programmes as well as in live performance." (Carroll).



[Fig. 7. Psychological Model of Teaching of Carroll]

Carroll's model does not deal directly with Box A and Box D of Basic teaching model of Glaser, but the existence of them is implicit. In applying his model, Carroll (1965) hopes for filling in the blanks in such statements as this : A student of age A and aptitude W requires X hours of training to attend Y proficiency in language L. About the usefulness of Carroll's model, Gage and Unruh (1969) write that such a model, applied to the study of teaching, would require other four variables be controlled or held constant by statistical covariance or factorial method. As determiners of the quality of teaching itself, Carroll identified such factors as listenability, readability, the structure and logic of the concepts presented, reinforcement schedules and incentives' system as important ones.

Mitra (1970) gave in outline form the features of a psychological theory of teaching. First, one has to consider the formulation of the teaching task. In formulating the teaching task in a given situation, the teacher makes an assessment of the stages of development of the learners with respect to the learning outcome finally to be achieved.

"In doing this assessment, therefore, a teacher should have a cognitive map in his head in which is delineated a goal and a path to the goal in terms of the subject-matter knowledge under consideration. While there is room here for individual organization of the cognitive map, it is limited usually by the logic of the subject or structure of the discipline, as it is called in education. The cognitive map is widely shared by teachers and has more or less clear-cut, area-wise and step-wise divisions through which the learner has to pass to reach mastery. The teacher only makes an assessment of the position of the pupil in this map. Where he is at the moment, how far he has to go in which direction etc."

".... the teacher must have a differentiated cognitive map of the behavioural domain for which he is responsible and that he must observe pupil behaviour relevant to the behaviours domain and form a judgment about his location in the map."

The teacher's judgment about the pupil's stage of devlopment is probabilistic, because he makes an estimate of the distance and path between the point where the pupil is in the cognitive map, and the end point which is fixed by the prescribed syllabus.

The strategy to be followed by the teacher in moving from the present locus of the pupil on the cognitive map to the end—point is thus determined by the subject-matter, the teacher's knowledge of the subject-matter and the teacher's knowledge of what other pupils in past have done. To this may be added, only one other consideration, viz., the teacher's judgment of the ability and motivation of the learner.

Gage (1966) maintained the view that the analysis of the concept of teaching is the first step towards building psychological models of teaching. The concept of teaching must be analysed into processes or elements that might properly constitute the subject of a theory.

First, teaching can be analyzed according to types of teacher activity. Sorenson and Husck (1963) mentioned six role dimensions of teachers: information-giver, disciplinarian, adviser, counsellor, motivator, housekeeper, record-keeper, curriculum planner, and evaluator.

Second, teaching can also be analysed according to the types of educational objectives. Tolman (1949) classified things to be learnt or the relations that get learned into six types: Cathexes, equivalent beliefs, field expectation, cognitive modes, drive discrimination and motor pattern.

Third, way of analysing teaching is based on components of the learning process. Miller (1941) set up four components of learning as drive, cue, response and reward. Corresponding components of teaching would be motivating, cue-providing, response-eliciting, and rewarding.

The final way to analyse teaching might proceed on the basis of the different families of learning theory that now seem useful.

Gage's favourite way of classifying these families refers to conditioning, identification and cognitive theories.

Gage (1967) proposed that teaching process in general be conceived as " the exertion of psychological force". Psychological force is hard to define but it involves the effects of stimuli that get into us via sensation and perception and act upon our central nervous system. According to him, there exists three kinds of teaching force. How these forces operate to produce learning is one problem to which theories of learning fall under three broad categories, conditioning theories, imitation theories, and cognitive theories. Teaching is conceived as three kinds of force that bring about learning. Hence we speak of teaching by conditioning the learner; teaching by modelling or imitation on the part of the learner, and teaching by changing the cognitive structure of the learner.

Conditioning Force: "Teaching by conditioning consists in arranging stimuli so as to bring forth desired responses and then providing a reinforcement as quickly as possible." Behaviours which are affectively toned, more bound with hope and fear, less with any logic are amenable to such teaching force.

Modelling Force: "Teaching by modelling consists in the teacher's behaviour in ways that he wants the learner to acquire through initiation." Such exposure to a model can have three kinds of effects:

1. A modelling effect, whereby the learner acquires new kinds of response patterns.
2. An inhibitory or disinhibitory effect, whereby the learner decreases or increases the frequency, latency or intensity of previously acquired responses.
3. An eliciting effect, whereby the learner receives from the model merely a cue for releasing a response, that is neither new nor inhibited.

This type of teaching force is needed for tasks that have little cognitive structure.

Cognitive Force: " Teaching, by changing cognitive structure consists in arranging for the student to understand facts, concepts and principles in such relationships that the desired kinds of learning will result. If we want a student to understand a strange phenomenon, we can force him to understand it by showing how it is merely an instance of a general principle.... In doing so, we can exert perceptual and cognitive force such as those of figure and ground; similarity and contrast; grouping; emphasis; analogy; context; logic. Properly used, these forces will make the student see the cues to a concept, a principle or the solution to a problem. These forces operate to bring about the change in cognitive structure that many kinds of learning consist in."

The distinguishing mark of learning that can be produced by the use of cognitive forces is that they possess a cognitive structure. The tighter the logical or perceptual ties that hold a body of ideas or behaviours together the better we can teach in this way.

Cognitive Theory of Teaching

Schooling is aimed at the acquisition of various kinds of cognitive knowledge, comprehension and understanding. In consequence, the important fact in the instruction process is the cognitive structure of knowledge.

Gage (1963) defined it as this: " Cognitive structure refers to the organization of facts, concepts, and principles. Such a structure is not arbitrary. It is determined partly by how man's mind works and partly by the nature of the subject, i.e. the ' intellectual discipline' to be learned. The cognitive structure of logical processes exerts force: it compels assents to a conclusion, for example, once appropriate premises have been stated."

Bruner (1961) defines the structure of knowledge as " — — — grouping the structure of a subject is understanding it in a way that permits many other things to be related to it meaningfully. The structure of knowledge is not contained in subject-matters taught in classrooms, because there the materials are atomistic, unrelated and in an inappropriate theme. It rather exists in such as mathematics, science, and language where the knowledge is disciplined by artful syntax."

Past researches on teaching are not cognitively oriented. (Ryans, 1960; Getzels and Jackson, 1963; Flanders, 1965). Recently efforts are being made towards "general, formulation of principles of teaching behaviour as related to achievement of cognitive objectives". Right from the sixties, research on cognitive aspects of teaching has been taken by many; of them mention may be made of Smith, Bellack, Taba, Ausubel, Gage, and Gagne.

Smith and Co-workers (1963) found that logical operation in defining a concept, formula or law is usually neglected in classroom teaching. They submit that quality of cognitive teaching improves with greater performance of logical operations in classsroom, such as defining, describing and such other processes.

Taba (1964) researched on formulating teaching strategies aimed at developing the ability of pupils in classroom to form concepts, make inferences, induce generalization and explain phenomena. In this connection what she says is very important. "Prolonged assimilation of facts without a corresponding reshaping of the conceptual schemes with which to organize them is bound to retard the maturation of thought. On the other hand, a premature leap into a more complex or a higher level of thought is likely to immobilize mental activity and cause reversion to,....., a lower level of thought,..... An appropriate transition from one to the other demands a proper match between the current level and that which is required. Determining the proper match is one of the most difficult tasks in teaching."

Thus, Taba's teacher is required to make quick and subtle judgments about the cognitive processes of his pupils when the discussion has got to the point that an attempt at generalization is called for.

Supplementary to this skill is needed the 'cognitive validity' of teaching behaviour of the teacher. About it, Gage (1970) wrote: "By cognitive validity I mean the degree to which the teacher possesses, and reflects in his behaviour, a valid, systematic, cognitive structure of the concepts and principles of the discipline he is trying to teach."

It is, therefore, the teacher's power or organizing and sequencing ideas, at the concrete and abstract level, of the knowledge of his subject.

Ausubel and Fitzerald (1961) drew attention to cognitive variables in teaching learning process. In this context, Gage (19:3) said: "As to paradigm for research on teaching, the cognitive structure variables imply more intensive concern with (1) teachers' own, understandings of what they teach and (2) how teachers behave along such dimensions as the 'logicality' of their classroom discourse . . . ."

A theory of instruction will also be concerned with the 'optimal structuring of knowledge'. Bruner (1968) wrote about it as such: "By this, I mean that for anybody of knowledge there is a minimal set of propositions, or statements, or images from which one can best generate the rest of what exists within that field. For example, from the conservation theorems plus a little more, a great deal of physics can be reconstructed. This is the 'guts' of physics."

By optimal structuring of knowledge, Bruner has three things in mind. The power of simplifying the diversity of information of a field. It constitutes the economy of structure. Then, such a structure will enable one to generate new propositions. This is the productiveness of structure. And finally, such a structure will increase the manipulability of knowledge and this is possible only by the transformative power of language. This is termed as the power of a structure.

Knowledge about anything can, generally speaking, be represented in three parallel ways, 'enactive representation of knowledge', 'ikonic representation', and 'represented systematically'. These modes of representation of knowledge make the structure of knowledge firmly based in the mind of the learner, catering to their individual channel of reception of it.

The teacher's role in engendering comprehension and other cognitive tasks in the academic discipline with which he is concerned, is a complex and puzzling one. What should he do if his behaviour is to have desired effect on the comprehension of his youngsters? Gage (1966) wrote in answer: "My answer, in very general term, is that the teacher will manipulate the learner's environment, in accordance with the laws of logic and cognition, in the same way that he can influence another person's perceptions by manipulating the environment in accordance with the laws of perception." Thus, the teacher, by exerting cognitive force can compel his students in the classroom to comprehend concepts and principles, and develop logical structure of a body of knowledge. Such an approach in systematization of teaching calls for the logical structure of subject-matter.

2.6 Towards Mathematical Models of Teaching

A mathematical theory seems to be an inevitable development at the present stage of every branch of the science of human behaviour. Research workers of widely diverse views are found to agree on this point. (Skinner, 1938 ; Brunswik, 1939 ; Wiener, 1948 ; Travers, 1956).

Dear and Atkinson (1962) write in this connection: "It does not seem necessary to present any argument here in support of the use of mathematical models in social science research, as the values of this method of study is now widely accepted." He pointed especially to the successes that mathematical modelling has had in three social science areas whose problems seem to overlap sufficiently with those of a programme of teaching, namely (i) mathematical learning theory; (ii) the theory of test design of measuring intelligence and achievement, and (iii) mathematical programming of dynamic problems like production scheduling, inventory control and process study.

Research on teaching, at present, is mainly 'descriptive' (Smith, 1956) and occasionally 'experimental' (Glaser, 1965). Though the majority of the studies are not 'prescriptive' (Bruner, 1966), fortunately they are not data-free. In a way, research on teaching is rich with variety and quality of available data necessary for preliminary model building. Empirical studies on teaching, both survey type and experimental type, have approached a critical point where model building may safely be taken of. Bush and Mosteller (1951) pointed out this direction of research in no uncertain term. "Mathematical models of empirical phenomena aid the development of Science when a sufficient body of quantitative information has been accumulated. This accumulation can be used to point the direction in which models should be constructed and to test the adequacy of such models in their interim states. Models, in turn, frequently are useful in organizing and interpreting experimental data and in suggesting new directions for experimental research."

Following the observations of Estes (1950) about statistical model of learning, we can also advocate meaningfully for mathematical approaches towards models of teaching. Reliable observational techniques and standardized collection devices used in 'class-room interaction analysis' (Flanders, 1970) and 'programmed instruction' (Fry, 1963), enable the present-day researcher in teaching to obtain data which are sufficiently orderly and reproduciable to support exact quantification of teaching process. Of course, some time is still needed for a comparable refinement of theoretical concepts and methods. What Estes (1950) said of learning may also be said of teaching in this matter. He said: "The necessary interplay between theory and experiment has been hindered, however by the fact that none of the many current theories of learning commands general agreement." Researchers on building theories of teaching are broadly classified into two groups "describers" and "improvers". The reason is not far to seek. Theories of teaching are built around verbally defined hypothetical constructs which are susceptible to certain disagreement on verification. To wait for the resolution of the varied disparities among the competing theories of teaching will be time-consuming and also in no way help to their resolution. The resolution rather lies in the way of systemization of "well established empirical relationship at a peripheral, statistical level of analysis" (Estes, 1950). The possibilities of unifying the diverse explanations of basic concepts in theories of teaching may be fruitfully explored through a set of experimentally manipulable variables, and by strict mathematical reasoning (Haddan, 1970).

Mathematical Models of Learning

The term "mathematical models of teaching" has not come even in occasional use in the literature of Educational research, although the same in learning is frequently used in psychological research. From 1870 onwards, the mathematical treatment of psychology, especially the branch of learning, has gradually evolved through experimental studies, psychometric studies, factor-analysis and finally in 1950, statistical studies.

Factor analysis techniques were developed and refined by Spearman (1927), Lawley (1940), Thurstone (1947), Thomson (1951), Kaiser (1956), Wherry (1959), and others.

Stochastic models were developed notably by Estes (1950), Bush and Mosteller (1951), Luce (1960), and others.

Information theory and Cybernetics were quickly drawn into the field of learning by Shanon and Weaver (1949), McGill (1954), Attneave (1959), Luce (1960), Stolurow (1965), and others.

Mathematical theory of teaching is almost the fraternal twin of that of learning and therefore, the building up of such a theory of teaching cannot be delayed. Necessarily it will draw heavily from the past experiences and present trends of building learning theories. The building of a model of teaching like learning, will involve 3 basic steps :

(i) constructing a quantitative theory of the phenomenon of teaching;

(ii) deriving empirical consequences (prediction) from the theory for the parametric values, time, paths, equilibria and other characteristics of the phenomenon ;

(iii) testing these consequences by comparing them with numbers derived from the empirical data.

Mathematical Models of Teaching

Henderson (1965) gave a theoretical model of teaching in which he had used the idea of a relation as a set of *n-tuples.* Teaching, he conceived a ternary relationship, T (x, y, z), where T is the variable, and x, y and z are component sets of teacher, pupil and subject variables respectively.

Biddle (1964) offered a " seven-variable model" for the investigation of teacher effectiveness. Gage (1963) had categorized his model with those of Medley and Mitzel (1958) and Ryans (1960) as " Criterion-of effectiveness " paradigm, Carroll (1965) also developed a comprehensive model of teaching involving five variables ; his model required the control of four variables by statistical methods like analysis of co-variance or factorial design. Siegel and Siegel (1967) suggested a paradigm entailing multivariate analysis and provision for studying interaction among the variables. The study involved four classes of independent variables and two types of dependent variables.

Factor-analytic Model of Teaching : Attempts have been made to develop a model of teaching through factor analysis. Factor analysis is a branch of statistical science which especially provides mathematical models for the explanation of psychological theories of human behaviour. Harman (1965) writes : 'The principle concern of factor analysis is the resolution of a set of variables linearly in terms of a small number of categories or factors. This resolution can be accompanied by the analysis of the correlations among the variables. A statisfactory solution will yeild factors which convey all the essential information of the original set of variables. Thus, the chief aim is to attain scientific parsimony or economy of description."

Factor analysis may identify the primary abilities that constitute the larger, general teaching ability as well as the specific teaching abilities of different subjects at different grade-levels and thus help to build a factorial model of teaching. Spearman's two-factor model, Holzinger's bi-factor model, Thurstone's multi-factor model, Wherry's hiearchical factor model, any and many of them may be experimentally utilised to study teaching ability. In fact, a large number of studies have already been undertaken to gain insight into the teaching process through factor analysis. (La Duke, 1945 ; Rostker, 1945 ; Hellfritzsch, 1945 ; Schmid, 1950 ; Ryans, 1952 ; Erickson, 1954).

Stochastic Model of Teaching : The statistical models of teaching may be deterministic or may contain random elements. Theories incorporating random elements are called stochastic. These probabilitistic mobels are becoming popular in social sciences, especially in different branches of psychology. Stochastic models can be interpreted in either of the two ways : the random elements as an integral constituent of the subject, or it is regarded as an artifact for summing up the unpredictable resultant of a host of minor and additive factors that influence behaviour. Researchers in learning theory are in the view that stochastic models in learning, in view of the existing limited knowledge of neurophysiology, seem likely to play a major role for a long time to come in advancing knowledge of human behaviour. Bush and Mosteller (1951) said : "We do not take a position of strict determinism with respect to behaviour and its prediction. We tend to believe that behaviour is intrinsically probabilistic...."

Although Estes (1950) initiated a movement towards a statistical theory of learning and vigourous research work has been done along the direction, no serious attempt has yet been consciously made to examine the possibility of their usefulness in building models of teaching. Few scattered attempts have, of course, been noticed.

Dear and Atkinson (1962) developed a somewhat mathematical model of teaching process which was concerned with a simple situation in which only two concepts were being taught. A " Two-state Markov chain " mathematical learning model was used as the principal tool for developing the teaching model. The study originated at the branching problem of a two-concept programme for efficient teaching.

Flechsig and Heipche (1969) proposed a didacometric model which is valuable to theorize the 'Interactive process' in teaching, because it was based on a special stochastic matrix relating the factor for the initial distribution to that of the final distribution of achievement scores. Didacometry, therefore, denotes a new field of instructional measurement which is concerned with the development and adaptation of mathematical models which permit to measure the effectiveness of instruction.

All in all, the roles of probability in a stochastic model of teaching will be :

(a) Assumptions that the teaching behaviour is determined only probabilistically by the elements of instruction.

(b) Assumptions that the behaviour is not solely determined by parameter values, but is subject to influence by myriad unknown causes.

Cybernetical Models of Teaching :

The development of quantitative instructional models related to cybernetics has had its beginning within the last 10 years. These models attempt to describe the process of optimalizing the sequence of instructional events in a controlled situation. Mullen (1969) writes : 'the application of cybernetics to the study of learing-teaching system begins from the notion that teaching is basically concerned with controlling a learning process.' He has also given a model, " a simple mathematical description of adaptive teaching (coupled Student-Teaching Machine) system " in Dunn and Holroyd (1969). Groen and Atkinson (1966) represented the instructional models as multi-stage decision processes which determine the efficiency of various orders of presenting learning materials. Smallwood (1962) formulated a simple instructional model in which the students' post-instructional performance is a function of the number and blocks of instructional matters and the probable time for working through these subject-matter blocks. Matheson (1964) investigated via simulation technique a number of sub-optimal strategies for the response-insensitive instructional conditions and found a net reward return of 1 to 7 for optimal strategies. Computer simulation models of cognitive processes offer a theoretically rich class of quantitative instructional models. Feigenbaum and Feldman (1963), Reitman (1965) and others have done considerable work in this field. This trend of developing models of cognitive processes shows great promise for the future in providing a formal basis for comprehensive mathematical model of teaching.

PART—III

CONCLUSIONS

3.1 Retrospect

It is time to finish the survey of the field of research on teaching theory. The main features of the field are on the whole explored, although some features may be left out. They are only of secondary importance. The basic impressions after the survey are given below.

The 1960's in the history of research on theories of teaching will be remembered as a decade of intensified examination, criticism and experimentation.

Meux and Smith (1964) identified three trends of research: (1) a purely descriptive study of teaching ; (2) a correlational study ; and (3) a study designed to discover generalizations. The first level of study is intended simply to describe the teaching behaviour so that the phenomenon of teaching can be better understood. The second level of study is one with the purpose of establishing correlations between certain designed variables relevant to the phenomena under investigation. The last type is essentially that of an experimental study specifically designed to discover cause-effect relationships on broad, predictive generalizations within the phenomena. Apparently, there are no studies on teaching at the present time that will yield the broad, predictive generalizations that are long-range goal of inquiry into teaching.

Anderson (1969) classified the researchers on teaching theory into two broad categories : (1) describers like Bellack (1966), Flanders (1965), Smith (1963), Jackson (1966) and the like : (2) Improvers like Glaser (1965), Skinner (1965), Stolurow (1965) and the like. Describers see improvers as tampering with humanistic values and improvers see the describers hopelessly bent on improving the knowledge of obsolescent forms. In

Chart 1 : Major Researches on Theory of Teaching

	Theory of Teaching	Researcher	Year	Design of Research	Area of Research
1	Analysis of Verbal Interaction in the class-room	Aschner, M. J.	1960	Descriptive, Category system	Cognitive content
2	Cognitive Structure theory	Ausubel, D. P.	1967	Experimental	Cognitive content
3	Theory of Teacher effectiveness	Barr, A. S.	1962	Correlation	Total teacher behaviour
4	Game model of teaching	Bellack, A. A.	1966	Descriptive, Category system	Cognitive and affective content
5	Seven-Variable model of teaching	Biddle, B. J.	1964	Empirical, predictive	Social climate of the class-room
6	Cognitive-Structure theory of teaching	Bruner, J. S.	1966	Logical, Experimental	Cognitive content
7	Problem-solving model of teaching	Fattu, N. A.	1965	Experimental	Problem-solving
8	Interaction analysis model of teaching	Flanders, N. A.	1965	Descriptive, correlational	Class-room verbal interaction
9	Explorative model of Teachers' explaining	Gage, N. L.	1968	Correlational	Cognitive content
10	Strategies of class-room teaching	Gallagher, J.	1968	Descriptive	Cognitive and affective content

11	Logic Tree model of teaching	Hickey, A. and Newton, J. M.	1964	Rational, conceptual	Cognitive content
12	Theoretical model of teaching	Henderson, K. B.	1965	Mathematical (Set theory)	Cognitive and affective content
13	The model of 'Good' teaching	Hughes, M.	1959	Descriptive, Category system	Cognitive and affective content
14	Rudiments of a Theory of teaching	Mitra, S. K.	1970	Empirical (Psychometric)	Cognitive and affective content
15	Pattern of Complex incidents in class-room teaching	Nuthall, G. and Lawrence, P. J.	1965	Experimental	Cognitive content
16	Information transmission model of teaching	Ryans, D. G.	1965	Correlational, predictive	Teacher characteristics
17	System-analysis model of teaching	Searles, J. E.	1967	Theoretical	Cognitive, affective and psycho-motor content
18	Multivariate model of teaching	Siegel, L.	1967	Statistical (MANOVA)	Teacher Behaviour
19	Logical analytic model of teaching	Smith, B. O. and Meux, O.	1963	Descriptive	Cognitive content
20	Cybernetic model of teaching	Stolurow, L. M.	1961	Technological, adaptive	Cognitive content
21	The model of teaching concepts	Taba, H.	1964	Descriptive, Category system	Cognitive content

between describers and improvers is found a handful of researchers like Bruner (1966), Travers (1966) Gage (1968), and others who are more oriented towards prediction and control. They have taken their data from the describers' hypotheses and the characteristics of comprehensiveness, reliability and operationalism from the improvers ' experimentations. The author intends to call them empiricists who, he hopes, will influence the research of seventies on theories of teaching most. The major researches on theory of teaching are shown in Chart (1).

The suggested theories of teaching in chart (1) do not fulfil all the needs for such a theory. Rather they create a feeling towards the basic needs of a serviceable, empirical theory of teaching for which the world of Education eagerly waits. The basic needs of such a theory may be projected in a bi-dimensional situation of teaching. One dimension holds the nature of knowledge-cognitive, affective or psychomotor. The other orthogonal holds the timeless controversy of science or spontaneity of teaching. This axis creates the insurmountable tension in the study of teaching. A rationalization of this is urgently required to overcome the crisis in theory building on teaching. The use of different conceptualizations of the variables and processes in teaching by various writers has its genesis within the vortex of this crisis. Anderson (1968) had in this connection some illustrations of apparent disunity among the theory builders.

The concepts of 'cognitive structure' as formulated by Bruner (1966) and Ausubel (1967), 'learning structure' of Gagne (1965) and 'logic tree' of Hickey and Newton (1964), whatever their variations in vocabulary and detail, are similar ideas and they ought to be assimilated in one another.

Again, the concepts of the instructional process as ' cyclical give—and—take ' by Smith (1963), Ryans (1965), Runkle and Stone and Leavitt as cited by Gage (1963), 'a pattern of structuring—soliciting—responding—reacting' as described by Bellack and his associates (1966) and 'a sequence of stimulus, response and reinforcement' as formulated by the programmed instruction school of Skinner (1950), Stolurow (1965) and others have common elements in them. These formulas ought to be recognised as such and brought together.

3.2 Prospect

One inference about the prospect of the research on theories of teaching should be made at the onset, on the basis of the survey of past literature. There are a great many studies devoted to a discussion of what teaching is. Instead of speculating over this concept, the more recent researchers could be benefitted if they took trouble to see how the concept had evolved in the course of past 50 years. Such a study clearly reveals a well-defined concept of what teaching is. Teaching seems to the author, first, constituted of a set of relationships and correlations between various classes of objectives, physical, social or artistic ; second, that between the characteristics of pupils and the objectives ; third, that between the characteristics of the teacher and the objectives; and finally the interrelations between the previous three taken together. It is the final act that gives meaning to the definition. Without it, the first three acts become meaningless in their uses in the context of teaching. The basis on which hopes for future research on theories of teaching are built may now be shown.

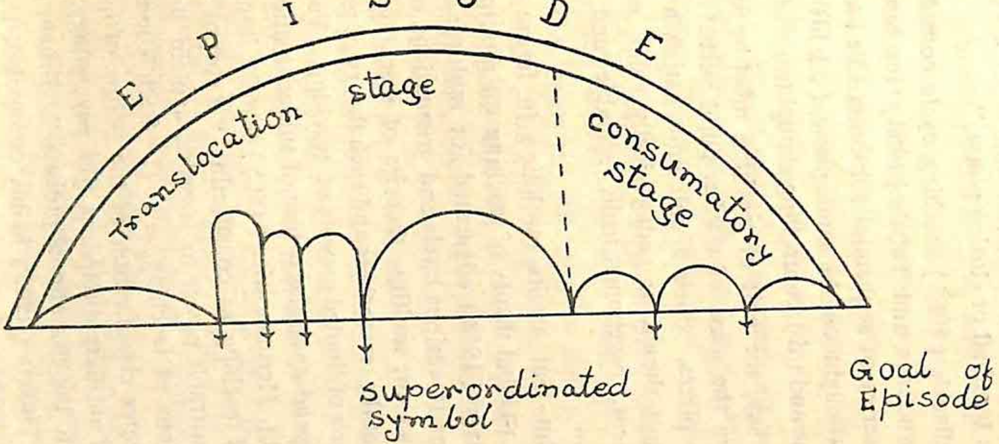
Cogen (1963) has rightly seen a ' New phase' because of the availability of devices for recording class-room behaviour in ways that make possible much more meticulous and repeated analysis of such behaviour-devices such as sound film and video-tape recorders. Gage (1967) pointed to a new road of analytic approach through micro–teaching where examination of relationships between finely discriminated aspects of learner behaviour and achievement is more intense and effective.

Another basic problem in developing a theory of teaching is concerned with what should be a unit of teaching behaviour. In the psychology of learning, Watson's concept of ' response ' has been recognised as a unit. Watson's unit is a " molecular " unit because it defines behaviour in terms of its strictly underlying physical and physiological details. The researchers in teaching find the stimulus-response micro-units inadequate for the meaningful, sequential, purposive behaviour such as teaching. As such the need for " molar " (Tolman, 1932) unit is clearly felt. This need is felt not only for the size of the unit but also for the qualitative context to which the unit belongs. The actions that are meaningfully performed are molar and those that are performed by reflex are molecular.

The nature of the molar unit of teaching behaviour may be better understood if the field of Vector Psychology be re-explored. Escalona (1968) named the largest meaningful unit in the division of a behaviour continuum as an 'episode' which should encompass an action from the first step in the direction towards a goal to the last step. Several sub-goals are attained on the road towards the main goal. The unit corresponding to the sub-goal is designated as a ' phase '. A ' phase ' is the smallest unit of molar behaviour. Each complete episode consists of two stages, the ' translocation ' and the ' consummatory '. The first one refers to the part of an action which consists of moving towards a goal, and consummatory refers to those activities which ensure once the goal has been reached.

Accordingly, researchers in teaching have defined teaching as ' a series of acts aimed at specific learning' (Mitra, 1970) or ' a system of actions directed to pupils' (Smith, 1960). Mitra (1970) justified his use of the term ' act ', avoiding the more familiar word ' response ' in context of teacher behaviour pointing to the sequential and cumulative characteristic of teaching behaviour.

Escolana's concept of the unit of molar behaviour has found its use in the context of teaching behaviour research of Smith and Meux (1960, 1970), where Smith and his associate have used 'episode' and 'monolog' as two kinds of units. An episode is a multispeaker unit, whereas a monolog is a uni-speaker one. Smith and Meux (1970) defined episode as this : "A unit of discourse involving a verbal exchange between at



[Fig. 8. Escalona's concept of unit of molar human behaviour] least two individuals. It passes typically through three phases : (a) an initial or opening phase ; (b) a sustaining or continuing phase and (c) a terminal or closing phase. "

Similarly Bellack's (1965) teaching cycle consisted of four types of basic structures and Taba's (1964) 'teaching strategy' consisted of a series of sequential sub-units like (a) focusing, (b) extending thought on the same plane, (c) lifting thought to a higher plane and (d) controlling thought.

Needless to say, the unit of teaching must be more than a means of cutting the mass of teacher-pupil verbal interaction into convenient pieces. Such a unit must satisfy a number of criteria. The unit should be pedagogically valid, neutral with respect to content, psychometrically scalable and of course reliable.

Another point that awaits resolution in future is whether there should be a global theory of teaching on multiple theories of teaching. Gage (1968) advocated for multiple theories of teaching, pointing to various levels and orientations of practical teaching. In his view, multiple theories of teaching will result from the effects of the researchers and each theory of teaching will offer explanations of limited aspects of teaching. Variations in theory might depend upon the nature of subject-matter and kind of children taught. Hermanowiez (1965) saw the importance of multi-theories of teaching as constituting " a corpus of knowledge with demonstrable power to describe, explain and control various dimensions of teaching. . . . . . Such knowledge also will provide greater classification of the points of convergence and relevance of ancillary disciplines like psychology, sociology and philosophy to the educational process. " Bruner (1966) by implication and Travers (1966) in his out-spoken manner had advocated for a theory of instruction which is comprehensive, scientific and all-inclusive. Smith too, in recent years, has spoken of a meta-theory of teaching.

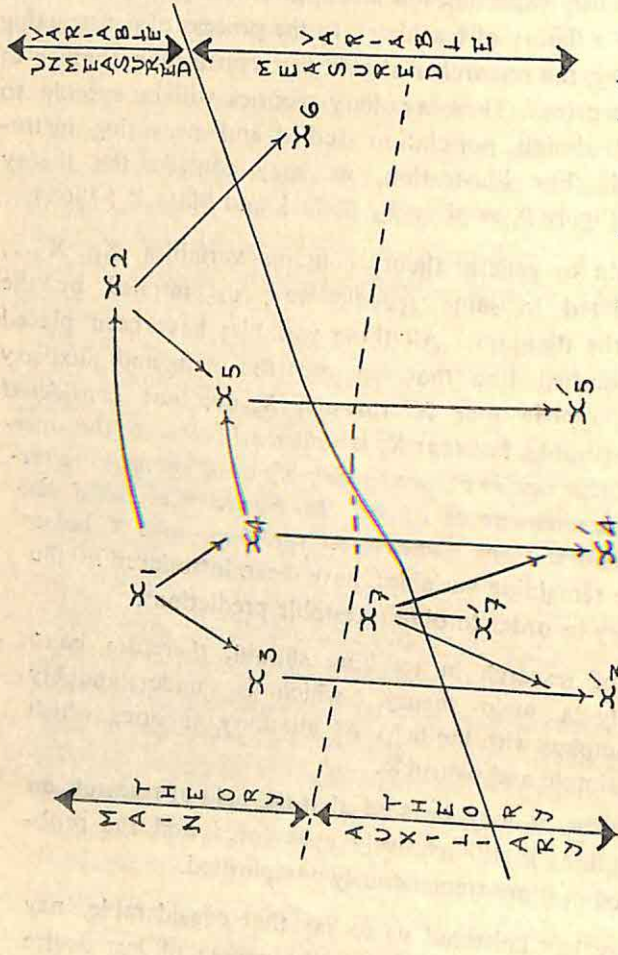
In the view of the author, on the one hand, there should be a general theory expressed in abstract terms, on the other there must also be specific auxiliary theories necessary for experimental purpose. The main body of a given theory might consist of a number of definitions, assumptions and propositions modelled after the ideal of a completely deductive system of thought. But this is obviously expecting too much, given the present status of research on a theory of teaching. In the process of constructing such a theory, the researcher should first construct a number of auxiliary theories. These auxiliary theories will be specific to the research design, population studied and measuring instruments used. For illustration, we may consider the theory implied by Figure 9, as given by Blalock and Blalock (1968).

The main or general theory contains variables X_1, X_2.., X_6 interrelated in same specific way, as implied by the arrows in the diagram. All these variables have been placed above the dashed line that separates the main and auxiliary theories. Suppose that X_1 through X_5 are not considered directly measurable, but that X_6 is sufficiently close to the operational level that one is willing to simplify the diagram by referring to its measurement as direct. In Figure 9 the solid line separates measured from unmeasured variables, with X_6 below the line. The remaining variables have been introduced in the auxiliary theory in order to obtain testable predictions.

The aim of research in teaching should, therefore, be to develop finally a main theory, which is understandably sufficiently complex, with the help of auxiliary theories which are relatively simple and plausible.

In conclusion, it may be said that the field of research on theories of teaching is still relatively unexplored and the problems embedded in it are tremendously complicated.

Our survey has bolstered us to say that considerable, nay marvellous work has been done in the course of last twelve years, the possibilities in the future are also 'calling' to researchers. There is not, perhaps cannot exist a body of received truth on the subject. It is felt that a theory of teaching is needed, it should be scientific and it can be built, not found, by honest labour.



[Fig. 9. Model involving distinctions between (1) Main and Auxiliary Theories and (2) Measured and Unmeasured Variables.]

The author has, therefore, no tested theory of teaching to offer. He would rather propose that working together a scientific theory of teaching be developed. He, therefore, invites the researchers in teaching with Bruner's (1963) prudent words :

> "*If we are to move toward a serviceable and sturdy theory of instruction—and I think we are—then your greatest contribution will be a willingness to give new ideas a try and full candor in expressing your reactions to how things worked. The prospect is strenuous, but gains to be won are enormous. I wish you well.*"

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